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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Vitali Nesterenko et al.	)
Serial No.:	10/531,553	)
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Filed:	May 2, 2006	)
For:	ISOSTATIC PRESSURE ASSISTED WAFER BONDING METHOD	)
Art Unit:	2823	)
Examiner:	Stark, Jarrett J.	)

DECLARATION OF VITALI NESTERENKO UNDER 35 U.S.C. § 132

I, VITALI F. NESTERENKO, declare that:

1. I am a co-inventor of the above-referenced application.

2. I received a doctorate in physics and mathematics from the Russian Academy of Sciences, Novosibirsk, in 1989.

3. I am currently employed as a professor of Materials Science at the University of California San Diego.

4. Cohn et al. (U.S. Pat. No. 7,276,789) teaches that hot isostatic pressing is a technique that can be used to bond metallic bonding features to metallic target features. Cohn fails to disclose application of hot isostatic pressing

to semiconductor wafers, which react differently to heat and pressure and have different bonding conditions than the metallic bonding features and target features disclosed in Cohn.

Moreover, the sole reference to hot isostatic pressing in Cohn states that "[s]till another alternative for supplying the necessary pressure and heat is to place a substrate pair into a high-temperature bag (made of a material as polyimide or metal foil) and subject it to hot-isostatic pressing." It is clear from this statement that Cohn suggests traditional hot isostatic pressing with vacuum encapsulation of wafers in a bag while embodiments of the present invention propose hot isostatic pressing of wafers without encapsulation in such a container. This is a crucial difference because semiconducting wafers, unlike metal wafers, are very sensitive to contamination which is likely to occur during a contact between the wafers and a material of the bag, especially under conditions of high pressure and temperature. In embodiments of the present invention, pressure is supplied by argon gas or by other gas directly to semiconducting wafers without contaminating the wafers with impurities. Additionally, Cohn's method necessarily requires an additional step of releasing the wafers from the encapsulating bag after the hot isostatic pressing. This releasing step is impractical in embodiments of the present invention due to the fragile nature of semiconducting wafers.

5. Curbishley et al. (U.S. Pat. No. 4,587,700) discloses that hot isostatic pressure is used to form a diffusion bond between a hollow cylinder and a

hub (see col. 4, lns. 26-29). The hollow cylinder is formed from a nickel-based superalloy such as MAR-M247 (col. 3, lns. 44-47). The hub is composed of a preconsolidated powder metal low carbon Astroloy, a fine-grained superalloy material (col. 3, lns. 66-68). Thus, Curbishley merely discloses that hot isostatic pressing can be used to form diffusion bonds in metal.

6. Boys (U.S. Pat. No. 5,215,639) teaches that hot isostatic pressing can be used to bond a target and a backing plate (see col. 6, lns. 50-57). While Boys fails to disclose a material for use as the target material, the reference teaches that the backing plate is formed of copper or aluminum (col. 6, lns. 8-10). Alternatively, Boys teaches that the backing plate and target may be a refractory metal with low plasticity, and an interstitial material such as copper or aluminum may be interposed between the backing plate and the target (col. 8, lns. 17-21). Thus, Boys discloses only that hot isostatic pressing can be used to bond metals.

7. Macris (U.S. Pub. No. 2002/0069906) discloses that hot isostatic pressing is a known technique for metallurgical bonding (paragraph [0013]), and for sintering related to bismuth, tellurium, selenium, and antimony thermoelements (paragraph [0027]). Macris further discloses the use of hot isostatic pressing to increase the density of thermoelements on wafers (see paragraph [0073]; [0075]). Each wafer is composed of a metallic or semi-metallic material (paragraph [0061]). Accordingly, Macris merely describes metal bonding.

8. Zhang (U.S. Pat. No. 6,521,108) teaches diffusion bonding of targets made from copper and cobalt, or alloys thereof with backing plate members made of an aluminum alloy (See col. 2, lns. 59-61; col. 3, lns. 9-10). Additionally, Zhang teaches that an interlayer formed from silver or a silver alloy (or other IB elements such as gold and alloys thereof, or VIII elements such as palladium, platinum, and their alloys) is used between the target and the backing plate (col. 2, line 66 - col. 3, line 3). That is, Zhang merely teaches diffusion bonding of metal bonding targets, a metal backing plate, and a metal interlayer.

9. Oda et al. (U.S. Pub. No. 2003/0134143) diffusion bonding between a tantalum or tungsten target and a copper alloy backing plate (see abstract, paragraph [0022]). Oda also teaches that an aluminum insert layer is interposed between the target and the backing layer (paragraph [0018], [0030], [0034]). Further, sheets of nickel and silver may be used as additional insert layers (paragraph [0034]). Thus, Oda merely describes diffusion bonding of metal components.

10. Takahashi et al. (U.S. Pat. No. 6,793,124) teaches that a high-purity cobalt target is bonded to a copper alloy backing plate (see abastract, col. 2, lns. 58-59). Additionally, Takahashi teaches that an aluminum or aluminum alloy insert layer is placed between the target and the backing plate (abstract, col. 2, lns. 63-65). Thus, Takahashi discloses a method of bonding metals.

11. Koenigsmann et al. (U.S. Pub. No. 2005/0115045) teaches forming a sputter target from a ferromagnetic material, such as nickel, iron, cobalt

or alloys thereof (see Koenigsmann, paragraph [0031]). A backing plate is formed from any number of metals, including aluminum, titanium, copper, and alloys thereof (paragraph [0034]). Also, a bond metal layer made from gold, silver, platinum, palladium, iridium, rhodium, ruthenium, or osmium may be applied between the sputter target and the backing layer (paragraph [0037]). Koenigsmann discloses that hot isostatic pressing is an advantageous method of forming solid state bonds between these components. Thus, Koeniggsmann only teaches that hot isostatic pressing is used to bond metals.

12. Stark (U.S. Pat. No. 6,962,834) teaches that a frame and a sheet are joined using hot isostatic pressing to form a hermetic seal circumscribing a window region (col. 19, lns. 33-37). The frame is a Kovar alloy/nickel/gold frame, and the sheet is a metalized sheet having aluminum as a final layer (col. 19, lns. 58-62). That is, Stark '834 only describes joining a metal frame to a metalized sheet.

13. Stark (U.S. Pub. No. 2005/0257877) discloses that diffusion bonding can be used to join a first layer, a second layer, and a substrate (see paragraph [0046]). The first layer is formed from an electrical conductor, a semiconductor, or an electrical insulator. The second layer is formed from an electrical insulator, and the substrate is formed from a semiconductor material (see abstract). Accordingly, Stark '877 fails to disclose that two semiconductor materials are bonded without an interlayer using hot isostatic pressing.

14. Yi et al. (U.S. Pub. No. 2009/0078570) teaches that a target and a backing layer are joined together via an interlayer. The target can comprise one or more of titanium, tantalum, zirconium, hafnium, niobium, vanadium, tungsten, copper, or a combination thereof. The interlayer can be formed of one or more of silver, copper, nickel, tin, titanium, and indium. The backing plate includes at least about 0.1 weight percent (%) of each of copper, chromium, nickel and silicon (see paragraph [0017]). Thus, Yi merely teaches joining metallic layers, and not semiconductor layers.

15. Bhat et al. (U.S. Pat. No. 5,207,864) discloses fusing two semiconductor wafers by applying heat and uniaxial pressure to the wafers (See Bhat col. 3, lns. 43-52).

16. Hot isostatic pressing described in the cited references is not functionally equivalent to the uniaxial pressing disclosed in Bhat for bonding of semiconductor wafers, since techniques used to form diffusion bonds in metals are not directly applicable to fusion of semiconductor wafers. Moreover, isostatic pressing is fundamentally different than uniaxial pressure application. That is, the different methods of pressure application cause different stress fields. Specifically, in uniaxial pressing the difference in stresses in the axial (i.e., the direction of force application in uniaxial pressing) and radial directions generates a shear stress which may result in wafer fraction under high uniaxial pressures.

17. At the time the above-referenced patent application was filed, those of skill in the art did not believe that hot isostatic pressing, particularly

without inhibition of pressure penetration between semiconductor wafers, would result in formation of stronger bonds between the wafers. It was not even known that fragile semiconducting wafers would be able to survive application of 200 MPa isostatic pressure which corresponds to 40516 kgf, a force equal to weight of about 20 SUVs (e.g., a Toyota 4Runner) stacked on top of each other, for a 2 inch diameter wafer.

18. To the best of my knowledge, use of hot isostatic pressing on weakly bonded semiconductor wafers without vacuum encapsulation was unique at the time the above-referenced application was filed.

19. All statements made herein of my own knowledge are true and all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

December 14, 2009

V. Nesterenko

Vitali F. Nesterenko